"AN EVALUATION OF CT IMAGING FEATURES WITH CLINICAL OUTCOME IN MODERATE TO SEVERE TRAUMATIC BRAIN INJURY"

DISSERTATION SUBMITTED TO

THE TAMIL NADU Dr. M.G.R MEDICAL UNIVERSITY, CHENNAI

IN PARTIAL FULFILLMENT OF THE REGULATIONS FOR THE

AWARD OF DEGREE OF M.D IN RADIODIAGNOSIS.

BY

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CERTIFICATE BY THE GUIDE

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November 26, 2013

To
Dr V B Arun Kumar
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The Institutional Human Ethics Committee, PSG IMS & R, Coimbatore -4, has reviewed your proposal on 10th May, 2013 in its expedited review meeting held at College Council Room, PSG IMS&R, between 2.00 pm and 4.00 pm, and discussed your application discussed your application to conduct the study entitled:

"An evaluation of CT imaging features with clinical outcome in a traumatic brain injury"

The following documents were received for review:

1. Duly filled application form
2. Proposal
3. Informed Consent Forms (Ver 1.1)
4. Data Collection Tool
5. Budget
6. CV

After due consideration, the Committee has decided to approve the above study.

The members who attended the meeting, at which your proposal was discussed, are listed below:

Name	Qualification	Responsibility in IHEC	Gender	Affiliation to the Institution Yes/No	Present at the meeting Yes/No
Dr P Sathyan	DO, DNB	Clinician, Chairperson	Male	No	Yes
Dr S Bhuvaneshwari	M.D	Clinical Pharmacologist Member - Secretary	Female	Yes	Yes
Dr Sudha Ramalingam	M.D	Epidemiologist Alt. Member - Secretary	Female	Yes	Yes
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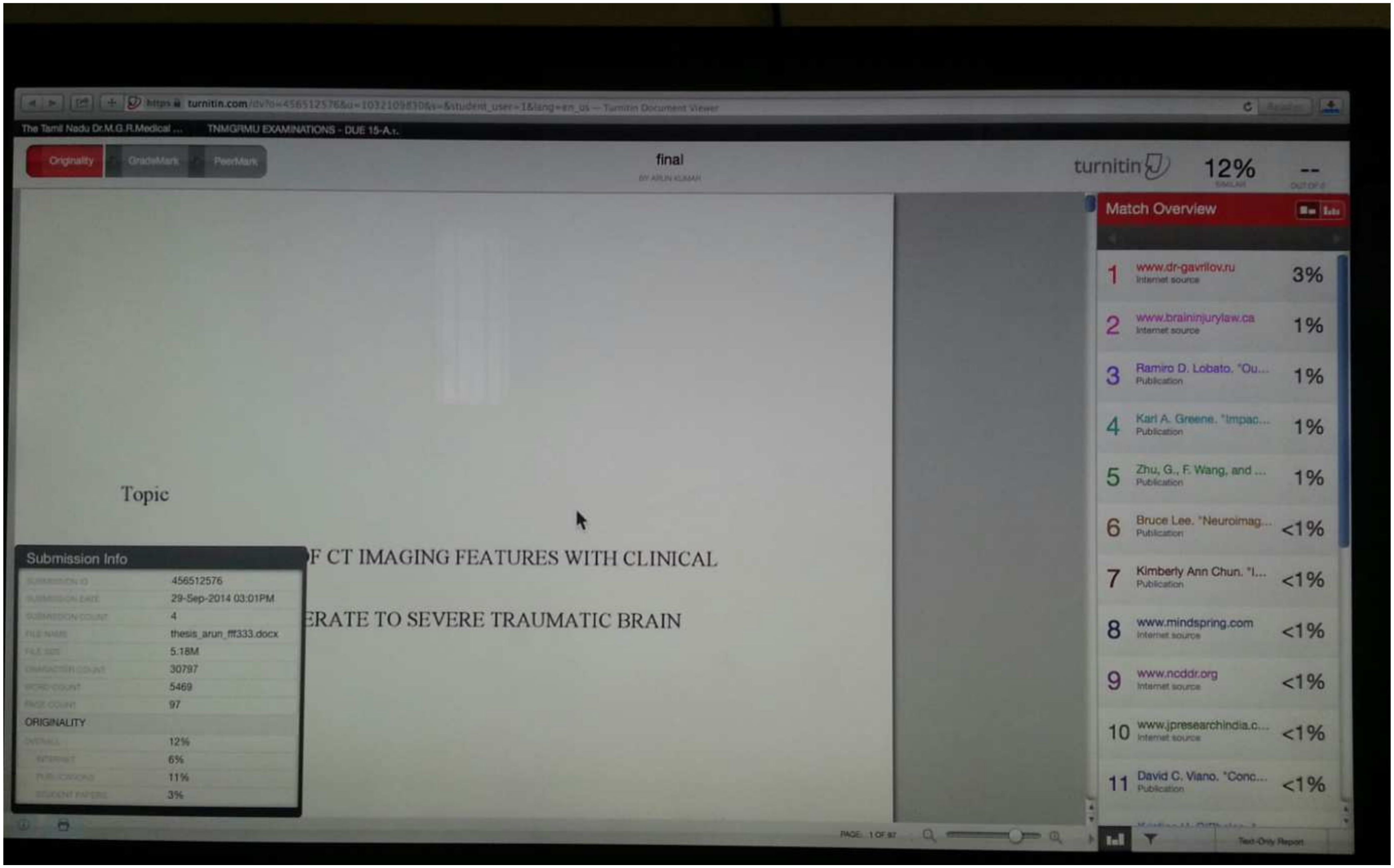
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ABSTRACT

AIM & OBJECTIVE

- To assess the imaging characteristic of primary brain injury on the first CT scan.
- Predicting the clinical outcome based on individual imaging features

MATERIAL AND METHODS

In our prospective cohort study, which includes 85 patients with moderate to severe head injury(<12), with positive neuro parenchymal findings on first CT scan of post trauma patients were included.

Individual imaging characteristic and their effect on patients mortality were assessed by statistical methods like chi square test and multivariate logistic regression analysis.

RESULTS

Regression analysis was used to asses mortality outcome gives significant p value for following factors like Basal cistern effaced – 0.042, Midline shift - 0.036, intra ventricular hemorrhage – 0.017, herniation – 0.08, Diffuse axonal injury 0.04

In our study mortality is more with a midline shift of >1omm, diffuse axonal injury grade 3, basal cistern effacement, intra ventricular hemorrhage, brain herniation .

CONCLUSION

Based on the study the individual multivariate parameters assessment is helpful in predicting the mortality rate and outcome of the patients. So here by conclude that initial CT imaging and its multivariate regression analysis can assess the outcome of the patient.

INTRODUCTION

Traumatic brain injury(TBI) is an insult to the brain from an external mechanical force leading to temporary or permanent impairment of physical ,cognitive, and psychological functions, which may lead to altered or diminished state of consciousness.

Traumatic brain injuries are the leading cause of morbitity, mortality and disability.1

The CT scan of patient is useful, not only in demonstrating the underlying neuro parenchymal injury but can also play a predictive role in traumatic brain injury 1

TBIs are the commonest cause of morbidity, mortality, disability and socioeconomic losses .

Commonest causes of traumatic brain injury are

- Falls,
- Motor vehicle accidents
- Assaults,
- Penetrating trauma and sports-related injuries

Severity of TBI is classified as mild, moderate and severe according to the traumatic brain injury patients the level of consciousness is measured by Glasgow coma scale (GCS). Most of the traumatic brain injuy patients who arrive to the hospital are already intubated or undergoes immediate intubation, ventilated and paralyzed .So accurate estimation of the GCS score or changes in the GCS score after post trauma in the initial hours is therefore difficult to obtain.

Due to availability, affordability and shorter scan time along with bone fracture delineation, CT is preferred over MRI as a primary investigation of traumatic brain injury.

Computed Tomography scanning of head is routinely done in all severe brain injury patients which provides information for further management including surgical intervention or intracranial pressure (ICP) monitoring.

It may also provide prognostic significance information.

Neuro parenchymal brain injury CT findings that are relevant for prognosis were

- Basal cisterns effacement,
- Traumatic SAH (t SAH),
- Presence and degree of midline shift and
- Type of intracranial injuries like epidural, subdural or intra cerebral hematomas, the roles of these variables, were evaluated individually and in combinations in various studies.

Predicting the diagnosis with early rapid management prevents from the complications of traumatic brain injury.

Rapid and good treatment can drastically improve patients condition.

CT findings helps in identifying the neuroparenchymal injury and grade the severity of the injury and operability status.

In unconscious patients complete neurological examinations cannot be performed , So CT Imaging can be useful in surgical planning and anatomical information for planning skin incision and burr holes placement.

Even though MRI is more accurate and sensitive in diagnosing neuroparenchymal pathology in traumatic brain injury patients, CT imaging is preferred because of following factors like

- Shorter time duration
- Less cost
- Performed easily when patient is uncooperative/ventilator support.

So it becomes initial modality of choice for traumatic brain injury.

MDCT has drastically reduced scanning time and motion artifacts.

CT imaging plays a major role in identifying and detecting the skull fractures , parenchymal and subarachnoid hemorrhage

Limitations of convential CT imaging are

- Beam-hardening artifacts/effects,
- Signal displacement (adjacent bones and metal objects) ,
- Calcification ,
- Small amount of blood can be missed (volume averaging).

CT done within three hours of trauma may underestimate injury as they lag behind actual intracranial damage.

It is under research whether to proceed repeated CT imaging in the absence of neurological status changes when admission CT was normal.

After forty-eight to seventy two hours of injury, MRI is found superior to CT. Even though CT identifies the bony defect and early hemorrhage, MRI detection of hematoma changes with the blood composition. MRI shows no abnormality in majority of mild traumatic brain injury patients .

The most common abnormal CT findings include

- Cortical hemorrhagic contusions,
- Altered white matter signal intensity
- Permanent hemosiderin deposition on MRI will be seen in resolving hematoma.
- Petechial hemorrhage

  MRI is better than CT in detecting

- Diffuse axonal injury,
- Small hemorrhagic contusion,
- Subtle neuronal damage.

Sensitivity of MRI is useful in the detecting sub acute and chronic hemorrhagic stages .

Sensitivity of MRI has improved with new MRI technology that includes

- FLAIR sequence
- Suppresses the high signal intensity
- It has more sensitivity in identifying traumatic brain injuries and hematomas

- McGowan and colleagues demonstrated sensitivity to MRI can be improved with magnetization transfer imaging where there is radio frequency to the protons in tissues rather than water protons .
- MRS is highly predictive tool in detecting axonal injury in traumatic brain injury patients.
- In mild TBI patients, Functional MRI is helpful in detecting activation of particular part of the brain .
- PET / SPECT imaging are not used routinely in acute traumatic head injury.

Limitations are

- lack of availabity
- longer scan time

PET and SPECT imaging gives only functional information [1-6]

AIM AND OBJECTIVE

OBJECTIVES

- To assess the imaging characteristic of primary brain injury on the first CT scan.
- Predicting the clinical outcome based on individual imaging features

MATERIAL AND METHODS

MATERIAL AND METHODS

STUDY TYPE	:	Prospective Cohort
STUDY PERIOD	:	July 2012 To Auguest 2014.
STUDY POPULATION	:	85 Consecutive head injury patients with positive neuro parenchymal findings in CT scan with GCS less than 12.
CT SCANNER	:	Siemens somatom definition edge.
		C2 level to vertex
		Mode –spiral non contrast
		Scan orientation- Caudo-cranial
		Scan time : 5 to 6sec
		Kvp/mA- 100 to120 kvp, 300 to 320 mAs

Inclusion & Exclusion Crireria

Inclusion criteria

Head injury patients with positive neuro parenchymal findings in CT scan with GCS less than 12.

Exclusion criteria

- Poly trauma,
- GCS more than 12

Criteria Flow Chart

Head injury Head injury patients with positive neuroparenchymal CT finding

with GCS less than 12

↓

assess the imaging characteristics of brain injury

↓

patient outcome is measured 6months after discharge

↓

predicting the clinical outcome based on individual imaging features.

Variables

Demographic variables

AGE

SEX

GCS

Independent variables

Extradural hemorrhage

Subdural hemorrhage

Subarachnoid hemorrhage

Intraventricular hemorrhage

Diffuse axonal injury

Hemorrhagic contusion

Herniation

Midline shift

Basal cistern effaced/compessed.

Dependent variable

Live

Death

Glasgow Outcome Scale (GOS)

Table: 1

Grade 1 - Good recovery	Resumption of normal activities even through there may be minor neurological or psychological deficits.
Grade 2 - Moderate disability	[Disabled but independent] patient is independent as far as daily life is concerned. The disabilities found include varying degrees of dysphasia, hemi paresis, or ataxia, as well as intellectual and memory deficits and personality changes.
Grade 3 - Severe disability	[Conscious but independent] patient depends upon other for daily support due to mental or physical disability or both.
Grade 4 - Persistent vegetative state	Patient exhibits no obvious cortical function.
Grade 5 - Death	

Statistical Methods

- Appropriate graphs and tables have been done.
- Association between categorical variables was performed using pearsons chi square test (fishers exact in case of 2x2 table)

Formula-($X^2 = \Sigma \frac{(O - E)^2}{E}$)

- Multivariate analyses were performed to see effect of CT finding in presence of other with mortality as dependent variable.

  Formula – ($Y=a + b_1X_1 + b_2X_2 + b_3X_3$)

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The Glasgow Coma Scale rates the patient's level of consciousness from 1 (worst) -- 15 (no impairment) based on patient's motor , verbal and eye response which is used to assess severity of traumatic brain injury[7-9].

Few studies shows that imaging is not required unless the GCS score is below 13[7-9].

European Brain Injury Consortium conducted a survey in patients with severe and moderate head injury where the GCS score was testable only in 56% of patients at the time of admission . Prognostic factors based on technical examinations results are therefore needed[7-9].

Based on CT findings focal and diffuse traumatic brain injuries can be classified[10] .

Marshall et al in 1991 analysed the Traumatic Coma Data Bank and proposed CT classification for grouping the patients where the classification identifies traumatic brain injury patients into six groups[10].

Further it was divided into four categories based on the patients with and without mass lesions[10].

Maas et al in 2005 had examined the Prognostic performance of traumatic brain injury by refinning and reevaluating the CT imaging characteristic helpful to form classification with additional CT imaging findings[10].

They developed a simple CT prognostic score (Rotterdam CT score) that are better than the Marshall scheme and have more association with clinical outcome when applied to Tirilazad Database which consists of 2249 patients[10].

Traumatic brain injuries are broadly classified as primary or secondary & diffuse or focal.

Primary lesions are

- Skull fracture,
- Scalp hematoma,
- Laceration
- Extradural subarachnoid and subdural hemorrhage,
- Intraventricular hemorrhage,
- Diffuse axonal injury,
- Hemorrhagic contusion,
- Deep cerebral gray matter injury

Secondary lesions are

- Cerebral herniation ,
- Diffuse cerebral edema,
- Traumatic ischemia/infarction.
- Hypoxic injury [11]

Extradural hemorrhage

Haemorrhage seen between the outer layer of dura and inner surface of the skull vault which results from fracture lacerating the middle meningeal artery/dural venous sinuses. It is associated with fractures in 85% to 95% [11]

EDH is usually unilateral but bilateral or multiple EDH have also been reported.

- Supratentorial (90-95%)
    - temporoparietal (60%)
    - frontal (20%)
    - parieto-occipital (20%)
- Infratentorially in posterior fossa (5-10%)

Biconvex shape which displaces the gray / white matter . out of which two third of them are of high density and one third are mixed density which indicates active bleeding. Most commonly located beneath the squamous part of temporal bone.

Depending on the size, secondary features which include midline shift and herniation will be present.In acute bleeding during CT will show the non- clotted blood as less hyperdense with swirl sign .

An extradural haematoma is limited by the cranial sutures and will be located with in the inner surface of the scalp between dura mater and bone.

Fracture with displacement of the extradural haemorrhages can cross the adjacent cranial suture.

Postcontrast extravasation will be seen in acute EDH.

Neovascularization and minimal enhancement (peripheral) will be seen in chronic EDH .[12-13]

Subdural hemorrhage

Cresent shaped blood collection between the dural and arachnoid meningeal layers are classified as subdural hemorrhage. Low GCS score on admission([15]) in a patient with subdural hemorrhage. subdural haematomas are usually unilateral (85 %).

Location - middle cranial fossa

- fronto-parietal convexities
- Common in cases of non-accidental trauma.

CT findings varies with time duration.

Hyper-acute

Appear isodense to brain parenchyma with swirling pattern appearing hypo in case of active bleeding. Part adjacent to swirling part predominantly appears hyper dense in most cases.

Acute

It is homogeneously hyper dense collection present extra axially in the hemisphere. Density will increase if clot retracts and SDHs have mixed hyper / hypo dense collection, which indicates blood which is not clotted, serum after clot retraction, or CSF within the subdural collection.

In case of severe anemia or coagulopathies, the acute SDHs will appear as isodense rarely.

Subacute

As clot advances and protein degradation occurs, the density decreases. By 10 - 14 days it becomes iso-dense to the adjacent cortex

Indirect signs are

- CSF filled sulci
- Mass effect
- Cortex thickening

Chronic

Subdural hemorrhage appears hypodense but sometimes becomes iso- dense to CSF.

Acute on chronic

Acute haemorrhage in a chronic subdural hemorrhage appears as hypodense in CT imaging ([15]).

Traumatic Subarachnoid Hemorrhage

Hemorrhage occurring in the subarachnoid space due to stretching or tearing of predominantly meningeal vessels, branch of external carotid artery . Association between severity of CT finding and presence of SAH with worse patient outcome.([12])

The sensitivity of CT in detecting subarachnoid blood is influenced by both the amount of blood and the time since the haemorrhage. The diagnosis is suspected when the subarachnoid space is filled with hyperattenuating material.

Traumatic SAH is seen around the circle of Willis or in the sylvian fissure.

Small amounts of blood can also be seen in the interpeduncular fossa, or within the occipital horns of the lateral ventricles [12]

Diffuse Axonal Injury

Diffuse axonal injury is the commonest cause of significant mortality resulting from axonal shearing forces in grey white matter interface, corpus callosum, and brain stem [21]

Mild diffuse axonal injury mostly not be seen in CT imaging. CT imaging appears as less sentivitity for diffuse axonal injury.

Some who had normal intial CT brain can have a diffuse axonal injury later will be detected in MRI.

The imaging features depends upon the presence of haemorrhagic lesions. Hemorrhagic lesions will appears as hyper dense and size is ranging from millimeters to centimeters . Non-hemorrhagic lesions will be hypo dense. Both types will be seen at the grey-white matter junction, in the corpus callosum and in the brainstem. . Diffuse axonal injury will be associated cerebral edema and Significant cerebral ewelling.

CT imaging is found to be insensitive in case of non-hemorrhagic lesions and only detects 19% non hemorrhagic lesions, where as MRI will detect 92% of such lesion [4]. In case of large hemorrhagic lesions CT is very sensitive. It is presumed that in small hemorrhagic lesions in the CT, there will be increased degree of damage and MRI is likely to detect more number of such lesions.

- DAI grade I – small hemorrhagic foci will be seen in between grey and white matter interfaces
  - periventricular temporal lobes ,frontal lobes, periventricular temporal lobes are commonest location.
  - Identified in MRS

- DAI grade II : small hemorrhagic foci in corpus callosum with grade I findings.
  - posterior body and splenium are commonest location is most frequently unilateral
  - identified in SWI
  - 20%
- DAI grade III : small hemorrhagic foci in brainstem with DAI grade1and 2 findings.
  - Rostral midbrain, superior cerebellar peduncles, medial lemnisci and corticospinal tracts [21] .

Hemorrhagic Contusion

It is the commonest primary traumatic brain injury. Commonly involved lobes are , frontal and para sagittal temporal

On CT appears as patchy ill defined low density lesions that may be mixed with smaller high density foci of petechial hemorrhage.

Most contusions occurs as a result of the brain force against the surface of the skull.

Cerebral contusions locations , depends on

- The skull cavity shape &
- Direction of head strike
- counter coup & coup injury anterior cranial fossa floor.

Hemorrhagic contusion will vary with shape and size with different patients.

Hemorrhagic contusions will change according to stages no weeks, hemorrhagic foci

In chronic stages the hemorraghic contusion will causes surrounding edema and produce gliotic changes. [22]

Intraventricular Hemorrhage

Defined as the presence of blood in the intraventricular system .On CT appear as high density intraventricular blood . it occurs in 1-5% of patients with traumatic head inury.([24-25])

Non contrast CT imaging plays an important role in evaluating onset of sudden headache and stroke.

On CT imaging, ventricles blood will appears as hyperdense more than CSF density.

It is predominately visualized in occipital horns.

Significant blood will tends to fill the ventricle, and resulted in clot formation.

The CT imaging findings will be helpful in identifying & differentiating obstructive hydrocephalus & ex-vacuo dilatation in the ventricles.

Consequence of severe trauma associated with diffuse axonal injury and trauma of deep grey and brain stem.[24]

CEREBRAL EDEMA

Massive cerebral edema with intracranial hypertension is the most life threatening [(26)]. Diffuse cerebral edema seen in 10-20 %[(27)], on CT it exhibits homogenously decreased attenuation with loss of grey and white matter interface with hyperdense cerebellum.

Increased water content of brain/ increased intravascular blood volume.

Vasogenic and cytotoxic edema coexist (Vasogenic edema immediately followed by cytotoxic edema) .

Evolves over 24-48hrs, generally resolves in 2 weeks.[26,27]

Brain Herniation

Commonest supra tentorial brain hernaitions occurs in TBIs are subfalcine, central trans tentorial and uncal herniation.

Subfalcine herniation is one of the most commonest type of herniation in TBIs.

Subfalcine herniation occurs mainly due raised intracranial pressure which causes brain displacement. [28,29]

Radiographic features

Subfalcine shift is evaluated by drawing line from falx to posterior most part of septum pellucidum on axial CT images.

Septum pellucidum shift can be measured (millimeter) by evaluating distance from the level of midline

Imaging Characteristic features are

- Dilated CSF spaces on one side of cerebral hemisphere
- Anterior falx asymmetry
- Dilated lateral ventricle on side with compression lateral ventricle on the controlateral side will be seen.

MRI

Coronal MRI is useful in identifying the herniation Intracranial hemorrhage or tumour results from unilateral pathologhy can cause mass effect and brain displacement.

Complications

Obstruction of the foramen of Monro results in contralateral hydrocephalus) compression of ACA branches results in anterior cerebral artery territory infarct .[28-29]

In 1983 Lobato RD et al noted that in the patients with severe traumatic brain injuries, there are large variations and characterizations in the type of intracranial lesion and clinical duration[30].

So it becomes important to divide these patients into subgroups for analyzing the factors which are influencing outcome[30].

Computerized tomography (CT) is useful in segregating the cases on the basis of pathological and helful in correlate anatomical findings with neurological changes .

They had observed following CT imaging patters in a series of 277patients. –

Pattern 1	–	pure extracerebral haematoma
Pattern 2	–	extracerebral haematoma plus acute hemispheric swelling
Pattern 3	–	single brain contusion, whether or not associated with neighbouring extracerebral haematoma
Pattern 4	–	Multiple unilateral contusion, whether or not associated with subdural haematoma
Pattern 5	–	Multiple bilateral brain contusions
Pattern 6	–	General brain swelling whether or not associated with small extracerebral haematoma
Pattern 7	–	diffuse axonal injury
Pattern 8	–	normal CT scans

And found that outcome with patients 1,3,6 and 8 was significantly better than patterns 2,4,5,7 (when assed with categories introduced by Jennett B, Bond M.(persistently vegetative state and dead, severe disability, moderate disability Good recovery)[30]

In 1979, A pilot study to determine the feasibility of Traumatic Coma Data Bank (TCDB) was undertaken. The objective of this study was to gather prospective data on a large number of patients suffering severe head injury so that specific questions regarding particular subsets of these patients could be addressed As expected, there was an extremely strong relationship ($p<0.001$) between intracranial diagnosis and outcome[27].

However this type of pooling of data will masks diffuse injury groups of patients. Where as these group of patients are high risk for infarct and intracranial hypertension with higher mortality rates as pointed out by Marshall et al. A general lack of recognition of the importance of certain CT findings led them to develop a new classification (TCDB CLASSIFICATION). Such classification would allow for early prediction of outcome based on factors like age, clinical status, CT findings are known.

The intent of this classification was two fold : 1) accurate classification of severe head injury and gives accurate prediction imaging diagnosis at the early time of the patient's evaluation about the fatal / nonfatal outcome condition. They divided the abnormalities seen in CT in to six categories. They found that there is a striking direct relationship between outcome and initial ct scan diagnosis. ($P=0.0002$) The CT imaging diagnosis has important and sensitivity in predicting the status of mortality ($P=0.0001$) When motor and age score included in the model in the CT scan often appeared to be a more accurate predictor of the ultimate course of patients[27].

In the TCDB classification,

In a study, head injury patients were subjected to CT and following parameters including age, Glasgow score (GCS), injury severity score (ISS), pupil score were studied, the CT scan was simply classified according to presence of hematoma . But classification was according to diffuse injury patients without hematoma were placed in the same category as with patients whose scan was normal. However model suggested that the CT was the more better predictor of clinical outcome than clinical baseline characteristics, also suggested that presence of any hemorrhage was predictive of a poor outcome.[27]

A good relationship between CT scan findings, the frequency of elevated ICP, morbitity and motality in the population indicates that the CT findings are strongly predictive of the likelihood of intracranial hypertension and that there is a relationship, perhaps not completely defined, between the degree of intracranial hypertension and the likelihood of the dead.

Marshall's classification[31 32] is tabulated below.

Marshall's classification

Table no: 2

Category	Definition
Diffuse injury I (no visible pathology)	No visible intracranial pathology seen on CT scan
Diffuse injury II	Cisterns are present with midline shift 0-5mm and /or : Lesions densities present No high or mixed density lesion > 25cc May include bone fragments and foreign bodies
Diffuse injury III (Swelling)	Cisterns compressed or absent with midline shift 0-5mm, no high or mixed density lesion > 25cc
Diffuse injury IV (Shift)	Midline shift > 5mm, no high or mixed density lesion > 25cc
Evacuated mass lesion	Any lesion surgically evacuated
Non evacuated mass lesion	High or mixed density lesion >25cc, not surgically evacuated

Karl Greene in1995 had told that subarachnoid hemorrhage was the one of the poor prognosis then the injury separately which is obtained on first admission CT scan with penetrating and non penetrating severe traumatic brain injury[33].

The present grading systems for traumatic brain injury had classify patients according to finding which is obtained on the first admission CT scan and their CT findings correlate with outcome not taken the presence of subarachnoid hemorrhage , the amount of subarachnoid hemorrhage and location[33].

Then they developed another new grading mentioned below for traumatic SAH that was significantly relating to the clinical outcome at the head injury patients discharge from the hospital with a study population of 52 retrospective head injury patients.

Grade 1	indicated thin Tsah (Less than or Equal to 5 mm)
Grade 2,	thick t SAH (greater than 5mm)
Grade 3	thin Tsah with mass lesion (s) and a shift less than or equal to 5mm (3A) or greater than 5mm (3B)
Grade 4,	Thick Tsah with mass lesion and shift less than or equal to 5mm. (4A) or greater than 5mm (4B)

In their study they have had concluded that basal cistern effacement was on the most significant factor in regression model, second most to basal cistern is thickness of traumatic subarachnoid hemorrhage at the time of discharge at Glasgow outcome scale.[33]

In the year 2005, ANDREW I.R.MASS ET AL from Erasmus Medical Center, Rotterdam, Netherlands not only analysed the existent marshall classification but also confirmed its predictive value. In addition it was found that additional discrimination can also be obtained by using full use of individual CT imaging characteristics particularly with mass lesion like EDH and SDH underlying the CT classification of marshall [10]

Rotterdam computed tomographic score given below was derived after studying a sample size of 2249.[10]

Rotterdam CT score

Table no: 3

Predictor value	**Score**
Basal cisterns	
Normal	0
Compressed	1
Absent	2
Midline shift	
No shift or shift less than or equal to 5mm.	0
Shift greater than 5mm	1
Epidural mass lesion	
Present	0
Absent	1
Intraventricular blood or SAH	
Absent	0
Present	1

Rotterdam CT score

Table: 4

Score	No of patients	Actual mortality %
1	36	0
2	600	6.8
3	773	16
4	465	26
5	261	53
6	114	61

But patients with mild head injury were not included in this study it was suggested that early predicting outcome in traumatic brain injury could be significantly improved by adding more CT imaging parameter to model and further characterization of CT imaging parameter viz, SAH / IVH, basalcisterns, midline shift, and mass lesions like(EDH Vs intradural lesions).

In traumatic brain injury, they suggested to use combinations of individual CT imaging features rather than the classification of marshall for prognostic purposes .[10]

Many studies had examined the various association between imaging findings in CT , severity of injuries and outcome in traumatic brain injury patients.

Other studies asseses whether the CT scan imaging findings will help in predicting the outcome, and suggested classifying — the trauma coma data bank (TCDB) classification, Marshall *et al*, etc.

Previous classifications has several problems which limits generalisability. Classifications in patients with severe head injury mostly are GCS<8[7-9].

Particular intracranial hematoma and the mass effect shows important impact over the decision to repeat CT scan. In times of clinical deterioration, scan CT was repeated and will not reveal necessary of surgical intervention. Few other studies have shown that no interventions were performed on repeat CTs until the patient had presented with coagulopathy, hypotension [34].

In traumatic brain injury, many study models (93%) are from high income countries[32].

Prognostic models which are frequently published are developed from small samples of patients, rarely validated on external populations and poor methodological quality. It is not useful for clinically practice

Only few models are from low and middle income population in developed countries (where trauma occurs mostly). There were only 2% models are taken from low income countries [32]

OBSERVATION AND RESULTS

OBSERVATION AND RESULTS

AGE

In this study , patients age were ranging from 16 to 70years.

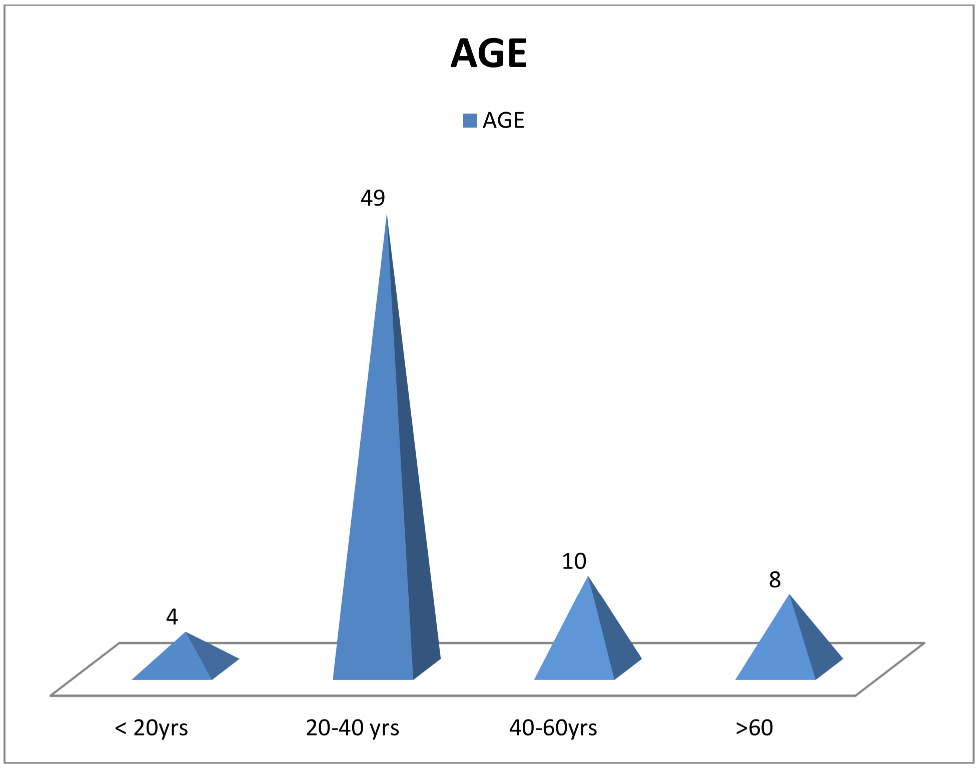
Out of 85 patients, 20-40yrs age group contributes maximum of 49 patients.

TABLE NO: 5

Age	No of patients
Less than 20yrs	4
20-40 yrs	49
40- 60yrs	10
>60yrs	8

GRAPH NO :1

AGE



SEX

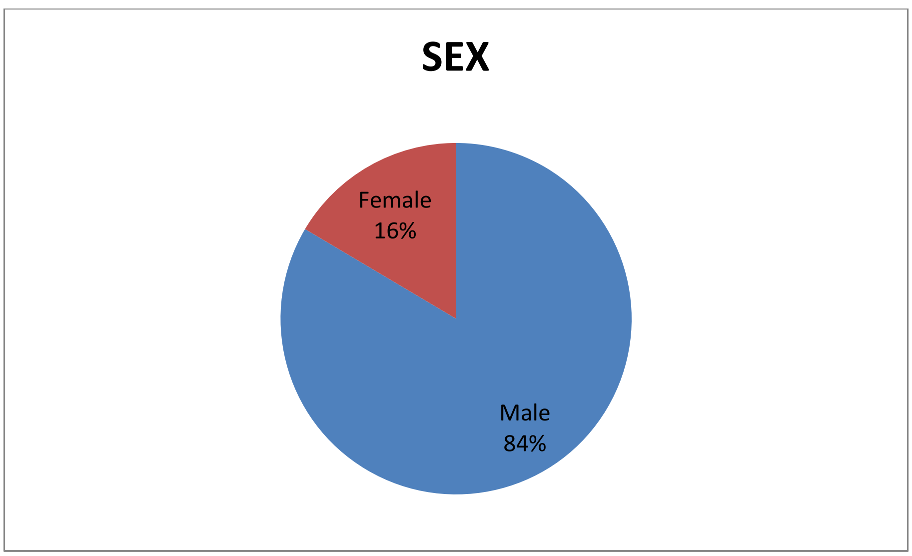
Out of 85 patients, study sample consists of 71 male and 14 female

TABLE NO: 6

Male	71
Female	14

GRAPH NO :2

SEX



GCS

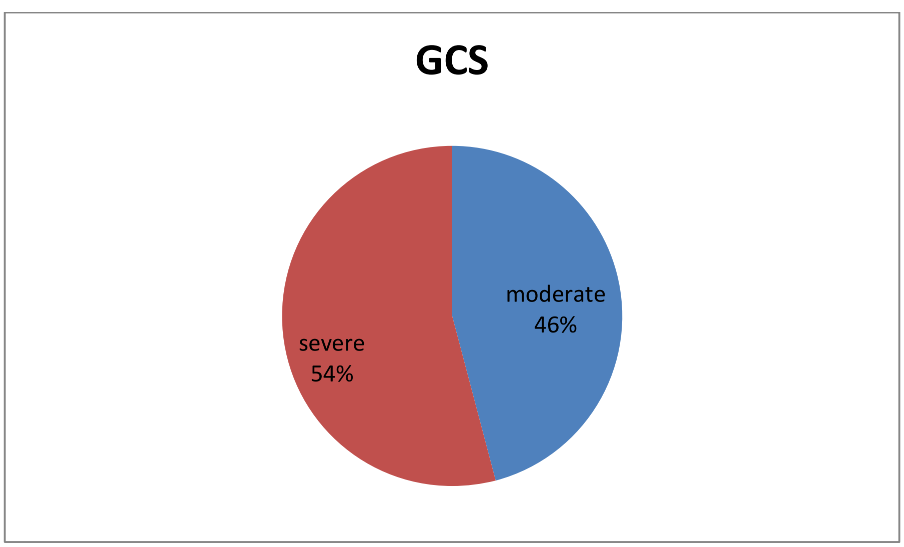
The mean GCS was 8 plus or minus 2 ranging from 1t012. A patient was considered to have severe head injury if GCS was 8or less which was observed in 46 patients and moderate head injury if GCS is between 12 to 9 which was observed in 39 patients

TABLE NO: 7

Moderate head injury	39
Severe head injury	46

GRAPH NO :3

GCS



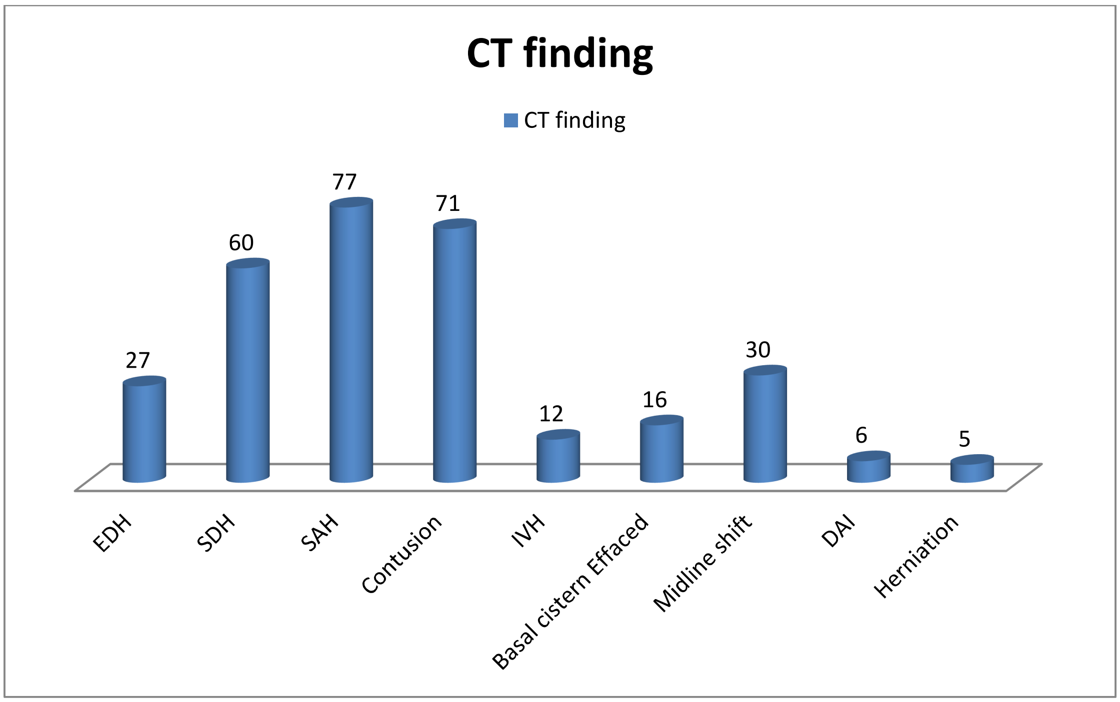
MAJOR CT Findings

TABLE NO: 8

CT FINDINGS	NO OF PATIENTS
Extra dural hemorrhage	27
Subdural hemorrhage	60
subarachnoid hemorrhage	77
contusion	71
intraventricular hemorrhage	12
Basal cistern effaced	16
Midline shift	30
diffuse axonal injury	6

GRAPH NO :4

CT FINDING



Extra Dural Hemorrhage

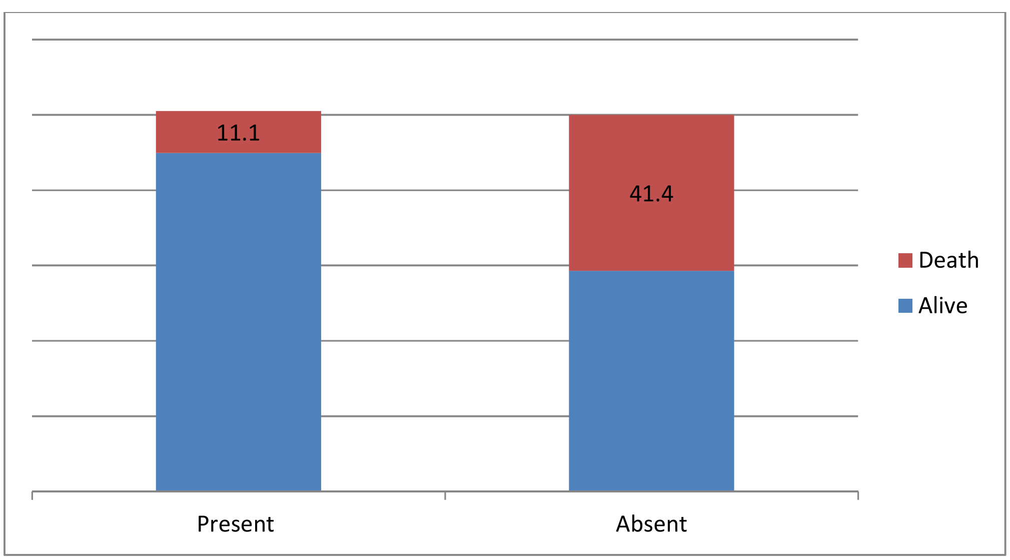
Out of 85 patients, extra dural hemorrhage were observed in 27 patients in whom three died.

TABLE NO: 9

EDH	Death	Alive	Total
Present	3 (11.1%)	24 (89.9%)	27
Absent	24(41.4%)	34 (58.6%)	58

GRAPH NO : 5

EXTRA DURAL HEMMORRHAGE



Subdural Hemorrhage

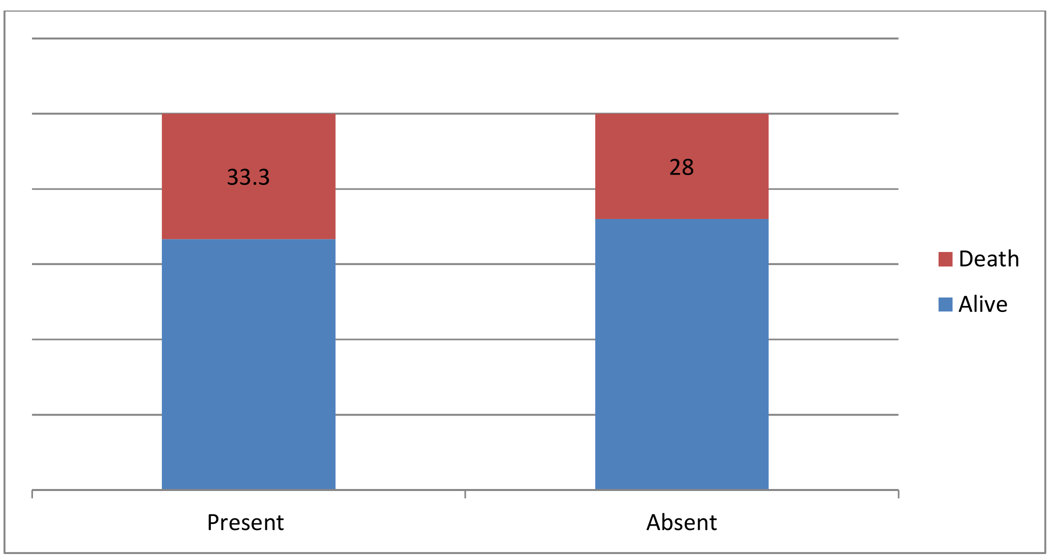
Out of 85 patients, sub dural hemorrhage were observed in 60 patients in whom 20 died.

TABLE NO: 10

SDH	Death	Alive	Total
Present	20 (33.7%)	40 (66.7%)	60
Absent	7 (28%)	18 (72%)	25

GRAPH NO : 6

Subdural Hemorrhage



Subarachnoid Hemorrhage

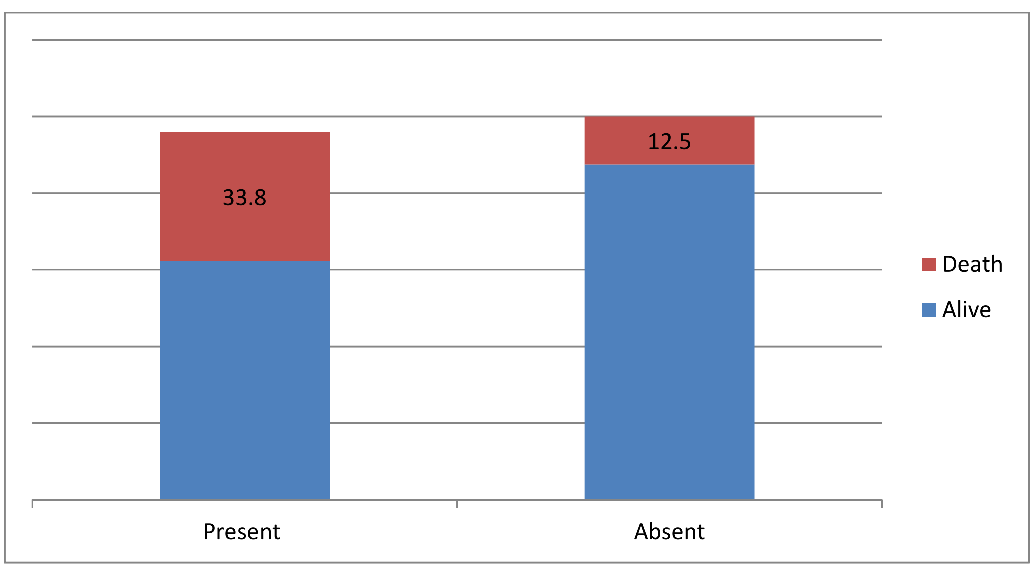
Out of 85 patients, sub arachnoid hemorrhage were observed in 77patients in whom 26 died.

TABLE NO: 11

SAH	Death	Alive	Total
Present	26 (33.8%)	51 (62.2%)	77
Absent	1 (12.5%)	7 (87.5%)	8

GRAPH NO : 7

Subarachnoid Hemorrhage



Contusion

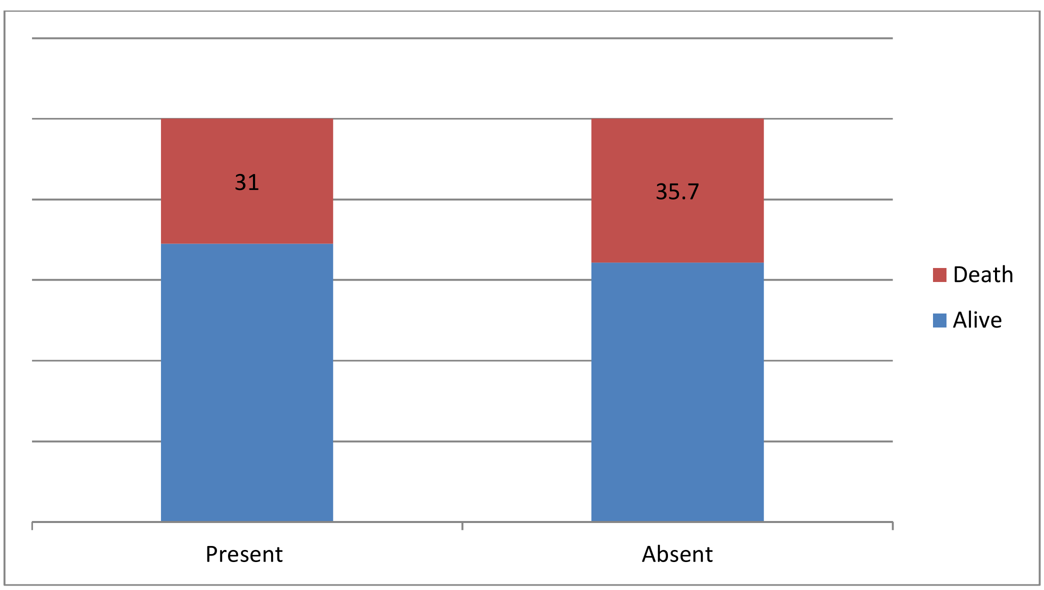
Out of 85 patients, Contusion were observed in 71patients in whom 22 died.

TABLE NO: 12

Contusion	Death	Alive	Total
Present	22 (31%)	49 (69%)	71
Absent	5 (35.7%)	9(64.3%)	14

GRAPH NO : 8

Contusion



Intraventricular Hemorrhage

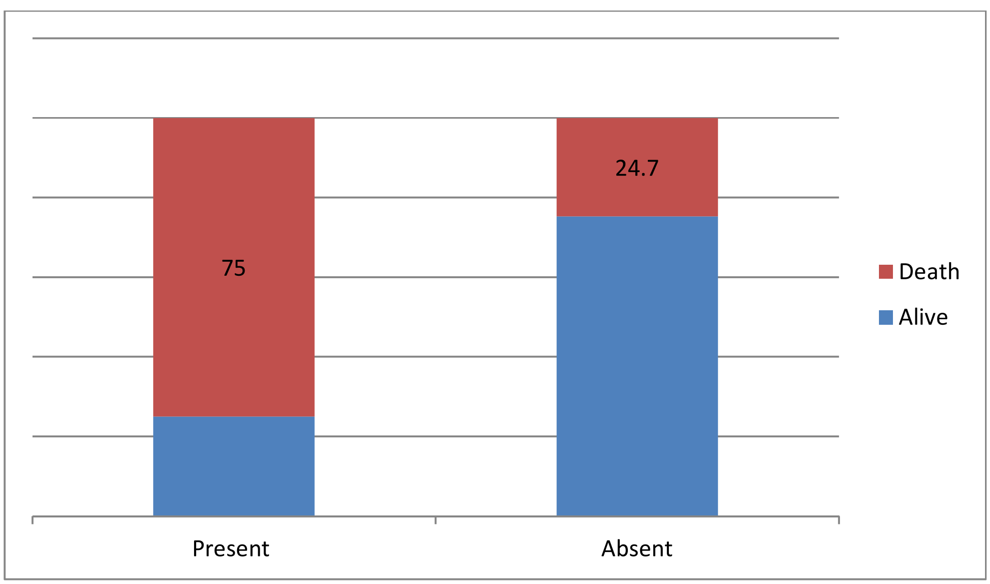
Out of 85 patients, Intraventricular hemorrhage wereObserved in 12 patients in whom 9 died.

TABLE NO: 13

IVH	Death	Alive	Total
Present	9 (75%)	3 (25%)	12
Absent	18 (24.7%)	55 (75.3%)	73

GRAPH NO : 9

Intraventricular Hemorrhage



Basal cistern Effacement

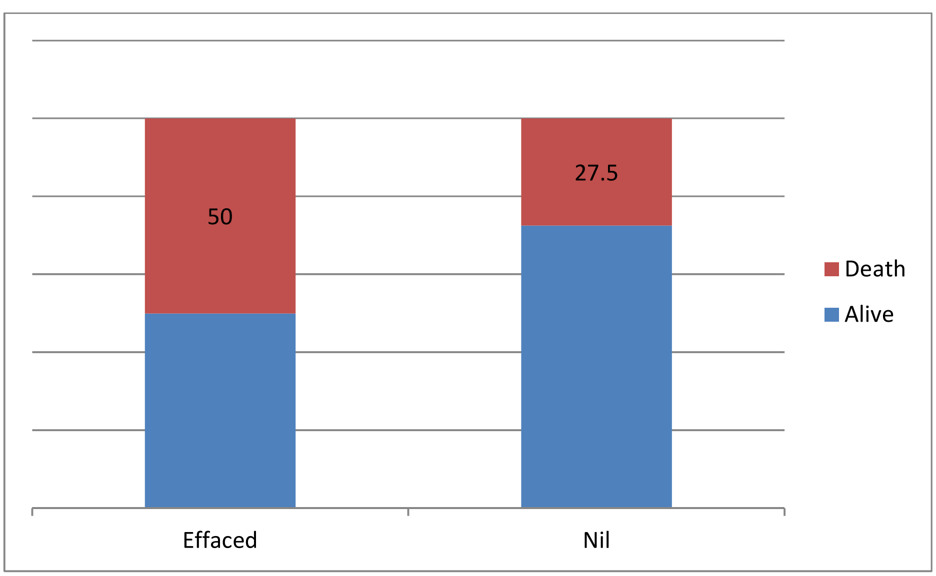
Out of 85 patients, Basal Cistern effacement wereobserved in 16 patients in whom 8 died.

TABLE NO : 14

Basal cistern effacement	Death	Alive	Total
Present	8 (50%)	8(50%)	16
Absent	19 (27.5%)	50 (72.5%)	69

GRAPH NO : 10

Basal cistern effacement



Midline Shift

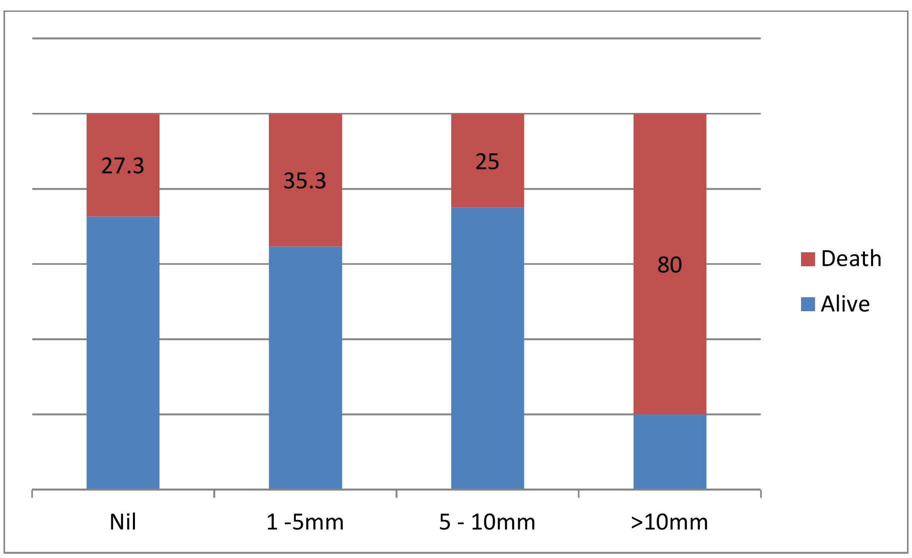
Out of 85 patients, midline shift were observed in 30 patients, in whom 12 died.

Table no: 15

Midline shift	death	alive	total
1-5mm	6(35.3%)	11(64.7%)	17
5-10mm	2(25%)	6(75%)	8
>10mm	4(80%)	1(20%)	5
absent	15(27.3%)	40(72.7%)	55

GRAPH NO : 11

Midline Shift



Diffuse Axonal Injury

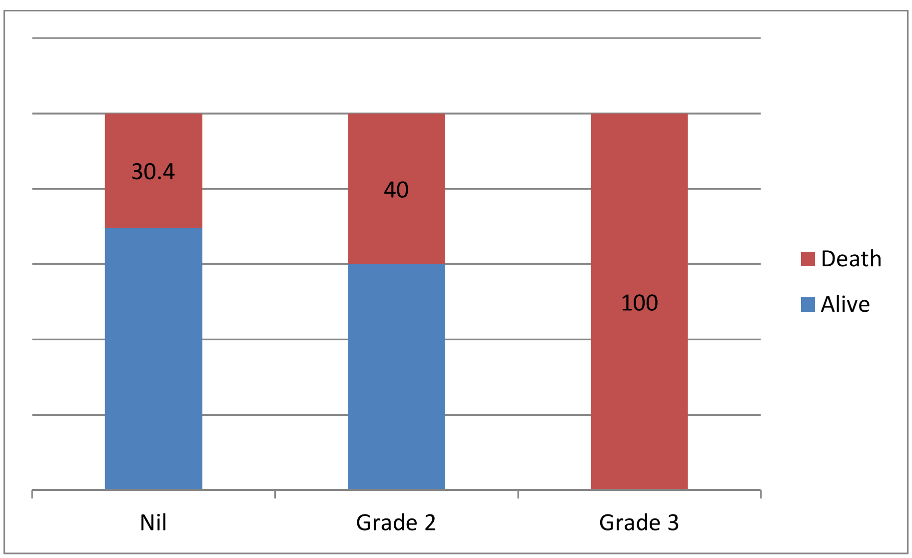
Out of 85 patients, diffuse axonal injury were observed in 6 patients in whom 3 died.

TABLE NO: 16

DAI	Death	Alive	Total
Grade1	-	-	-
Grade2	2(40%)	3(60%)	5
Grade3	1(100%)	0	1
absent	24(30.4%)	55(69.4%)	79

GRAPH NO : 12

Diffuse Axonal Injury



Herniation

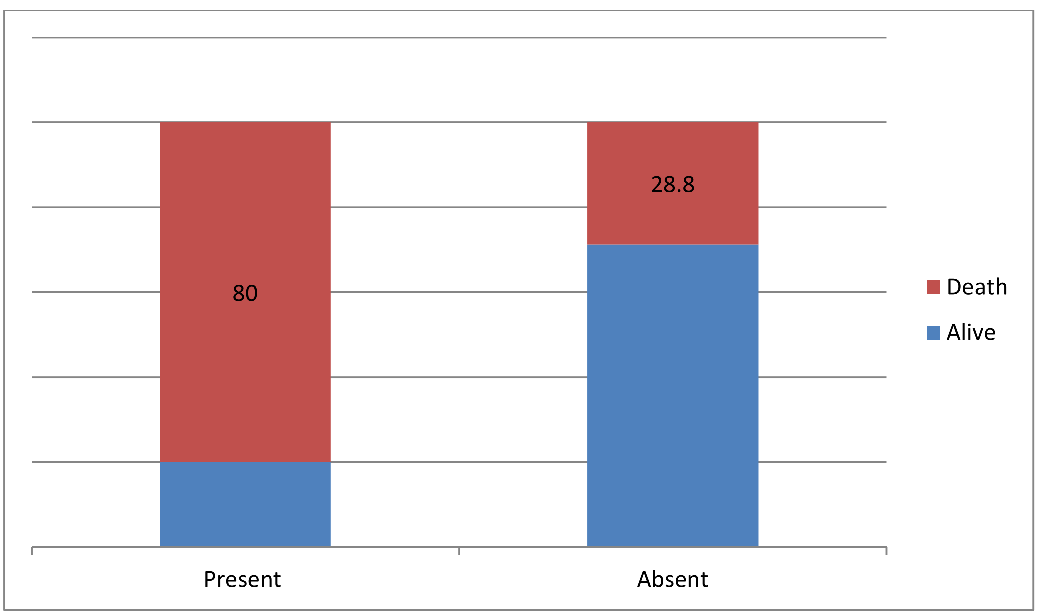
Out of 85 patients, herniation were observed in 5 patients in whom 4 died.

TABLE NO : 17

Herniation	Death	Alive	Total
Present	4(80%)	1 (20%)	5
Absent	23 (28.8%)	57 (71.2%)	80

GRAPH NO : 13

Herniation



Total no of Patients (Glascow Outcome Scale)

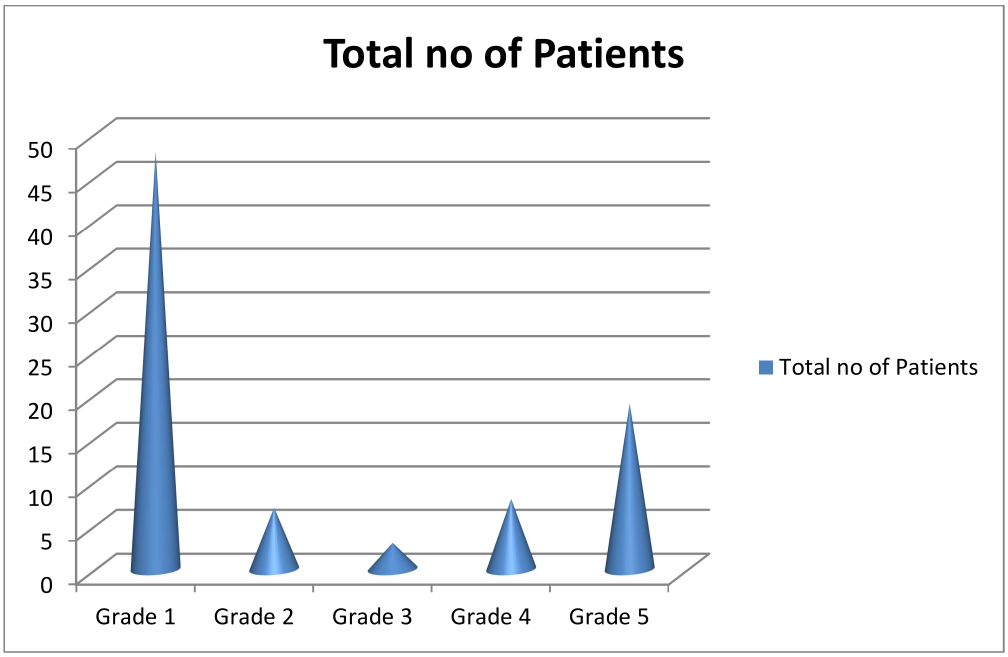
Out of 85 traumatic brain injury patients (GCS less than 12)

TABLE NO: 18

Glascow Outcome Scale	**No of patients**
Grade1	48
Grade2	7
Grade3	3
Grade4	8
Grade5	19
Total	85

GRAPH NO : 14

Total no of Patients (Glascow Outcome Scale)



DISCUSSION

DISCUSSION

India has 1% of the worlds vehicles, but 6% of total global RTA deaths . Economic loss amounts to Rs 550 crores (most of the RTAs effect the brain).

Assessment of prognosis of traumatic brain is one of the neglected areas in research barring a few attempts to create scoring system.

First CT scan of traumatic brain injury patient is used not only in diagnosing neuroparenchymal injury but also plays predictive role.

Various classification system like one given by marshall et al 1991 to the recent Rotterdam scoring system 2005 have been applied to assess prognosis of the patients.

Study was compared with Marshall and Rotterdam CT scoring systems, individual findings of CT which in included in these analysis system to predict the early mortality of patient having traumatic brain injury.

The marshall et al traumatic coma data bank classification includes.

Diffuse injury - 1,

Diffuse injury - 2,

Diffuse injury - 3,

Diffuse injury - 4,

Evacuated mass lesion - 5,

Non evacuated mass lesion - 6

The Marshall scoring mainly depends on the basal cistern involvement, middle line shift, evacuation and non evacuation mass lesion.

According to the Marshall et al CT finding and type of hemorrhagic mass management, patients with involvement of high or mixed density lesion with in brain >25cc volume not surgically removed has bad prognosis and high mortality score is near to 6 (P value < 0.0001).

Rotterdam (2005) CT scoring system includes

Traumatic subarachnoid hemorrhage along with basal cistern effacement, midline shift, EDH, intraventricular hemorrhage.

Based on the Rotterdam scoring the score of 6 has mortality 61% having basal cistern effacement, midline shift present >5mm, epidural hematoma , Intra ventricular hemorrhage , adding all of this with 1. P value of <0.0001 in a score 6 has a high mortality rate.

As compared to Marshall et al and Rotterdam scoring in our study individual parameters in CT findings show significant P value suggesting high mortality in following parameters like basal cistern effacement, midline shift, diffuse axonal injury .

In our prospective cohort study, which includes 85 patients with moderate to severe head injury(GCS<12), various CT parameters (observed on first CT scan post trauma) were studied for their effect on patients mortality.

The results were analysed .

Association between categorical variables was performed using pearsons chi square test (fishers exact in case of 2x2 tables).

Multivariate analyses were performed to see the effects of a CT finding in presence of other with mortality as the dependent variable.

It chi square test tells about the relationship between outcome of the patient and each variable. Chi square formula -($X^2 = \Sigma \frac{(O - E)^2}{E}$)

Associated variables are

Midline shift

Basal cistern

Intra ventricular hemorrhage

Herniation

Diffuse axonal injury

Hence, multivariate regression analysis results showed that above mentioned variables are closely associated with outcome of the patients who encountered head injury. Formula – ($Y=a + b_1X_1 + b_2X_2 + b_3X_3$)

CT findings that were statistically significantly indicative of mortality in multivariate scenario were

Basal cistern effaced – 0.042

Midline shift - 0.036

Intraventricular hemorrhage – 0.017

Herniation – 0.08

Diffuse axonal injury – 0.04

The primary advantage of predicting percentage mortality is especially important in country like ours, where there are limited financial resources.

This will help the patients family to have a better insight about the patient condition and the likely outcome.

SUMMARY

SUMMARY

- In our prospective cohort study, which includes 85 patients with moderate to severe head injury(<12), with positive neuro parenchymal findings on first CT scan of post trauma patients were included.
- Individual imaging characteristic and their effect on patients mortality were assessed by statistical methods like chi square test and multivariate logestic regression analysis.
- we concluded that following CT imaging findings like
    - Intraventricular hemorrhage
    - basal cistern effacement
    - midline shift more than 10mm
    - grade 3diffuse axonal injury
    - brain herniation

were noted to affect patients mortality adversely .

CONCLUSION

CONCLUSION

In our study, following factors on baseline CT scan were noted to affect patients mortality adversely.

1) 75% of patients with mortality had intraventricular hemorrhage .
2) 50% of patients with mortality had basal cisterns effaced.
3) 80% of patients with mortality had midline shift more than 10mm. 25 – 35% patients with mortality had midline shift below 10mm.
4) Prognosis of diffuse axonal injury worsens with its grades, highest with grade 3 seen in 100% of patients with mortality.
5) 80% of patients with mortality had herniation
6) In our study less than 15% of patients with mortality had subdural hematoma and 33% of patients with mortality had subarachnoid hemorrhage.
7) Regression analysis was used to asses mortality outcome gives significant p value for following factors like
    - intraventricular hemorrhage
    - basal cistern effacement
    - diffuse axonal injury
    - herniation
    - midline shift

8) The predicted percentage of mortality gives a better insight about better condition outcome to patients family where it can help them for financial aspect and it also help their family to decide on the expensive therapeutic option.

LIMITATIONS AND RECOMMENDATION

LIMITATIONS

- In our study, we are not able to accomplish large population group due to loss of patients follow up and inadequate volume of cases(moderate to severe traumatic brain injury).
- Combination of individual imaging features not assessed.
- We have not included the mild head injury patients who can also have less chance of mortality

RECOMMENDATIONS

We recomment combination of individual CT imaging features in a large group with wide characterization of individual imaging features.

IMAGES

Figure 1 : EXTRADURAL HEMORRHAGE

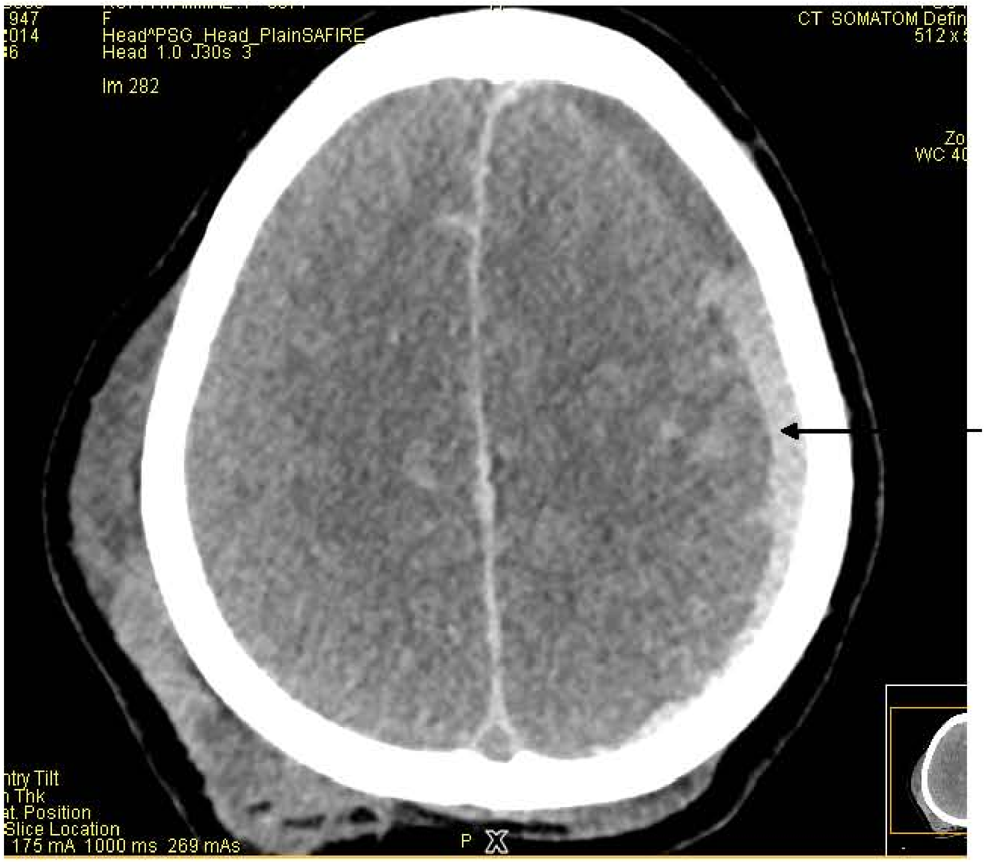


Figure 2 :SUBDURAL HEMORRHAGE

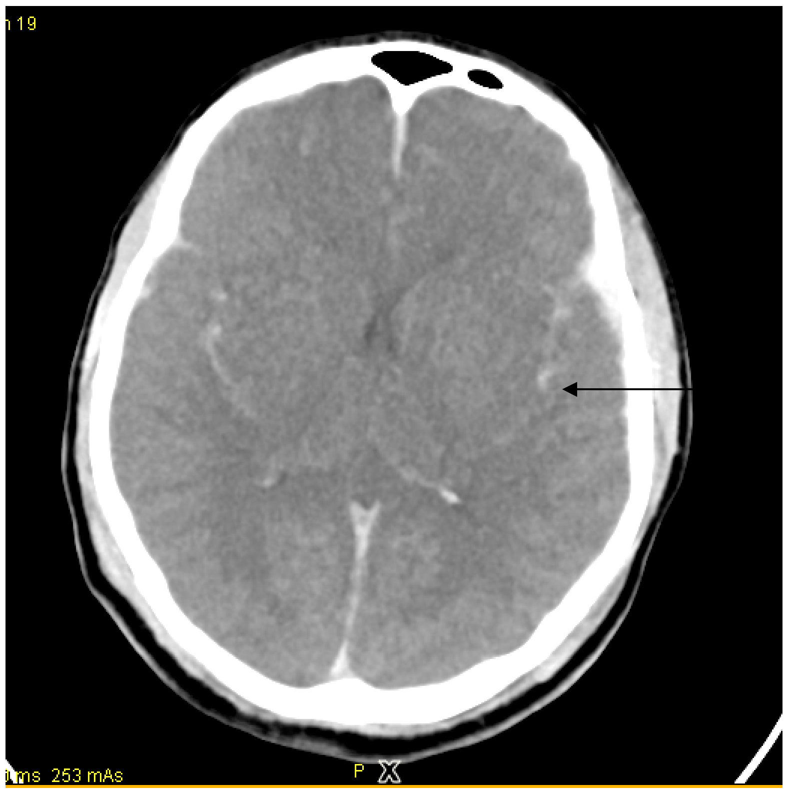


Figure 3 : SUBARCHNOID HEMORRHAGE

Figure 4 : HEMORRHAGIC CONTUSION

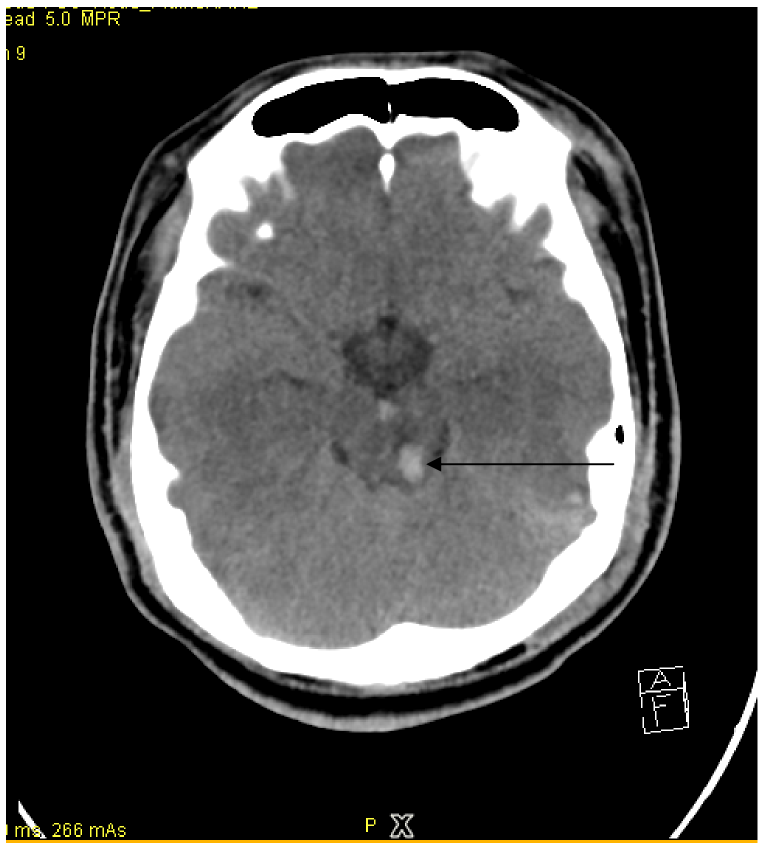


Figure 5 : DIFFUSE AXONAL INJURY

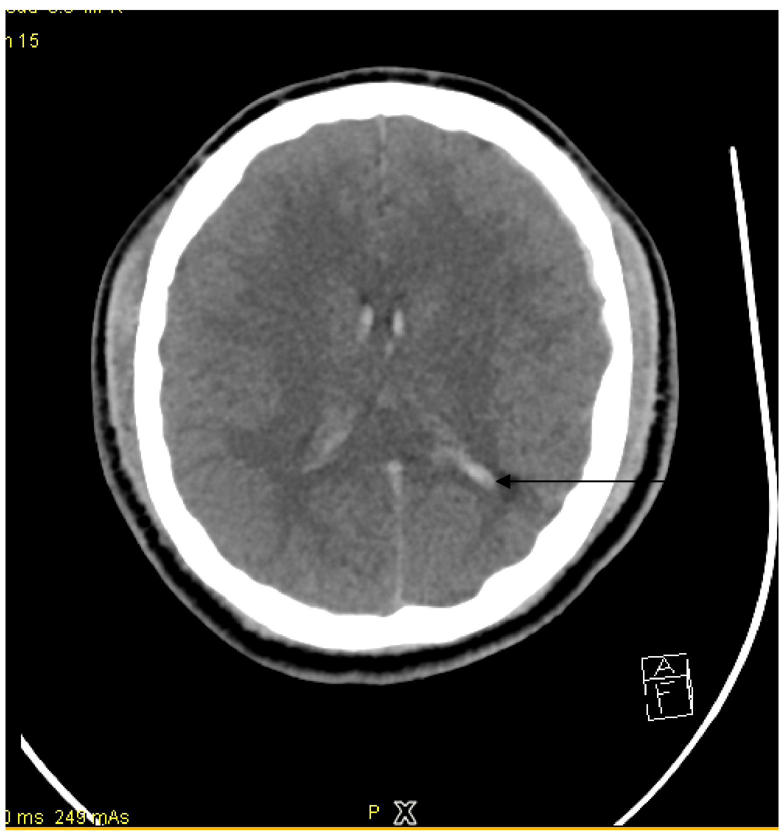


Figure 6 : INTRAVENTRICULAR HEMORRHAGE

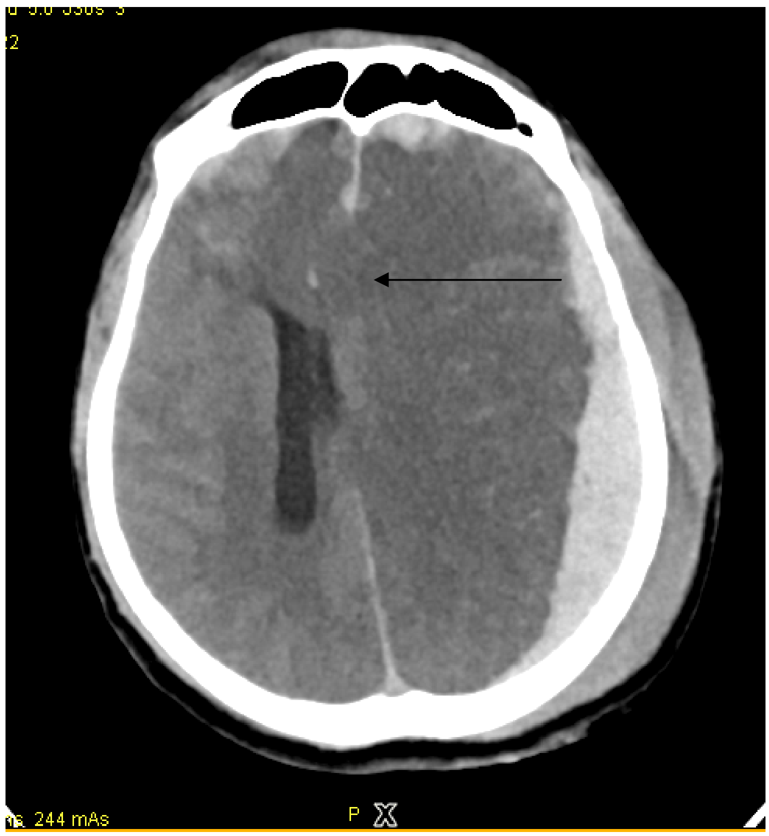


Figure 7 : Subfalcine HERNIATION

Figure 8 : Uncal herniation

Figure 9 : MIDLINE SHIFT

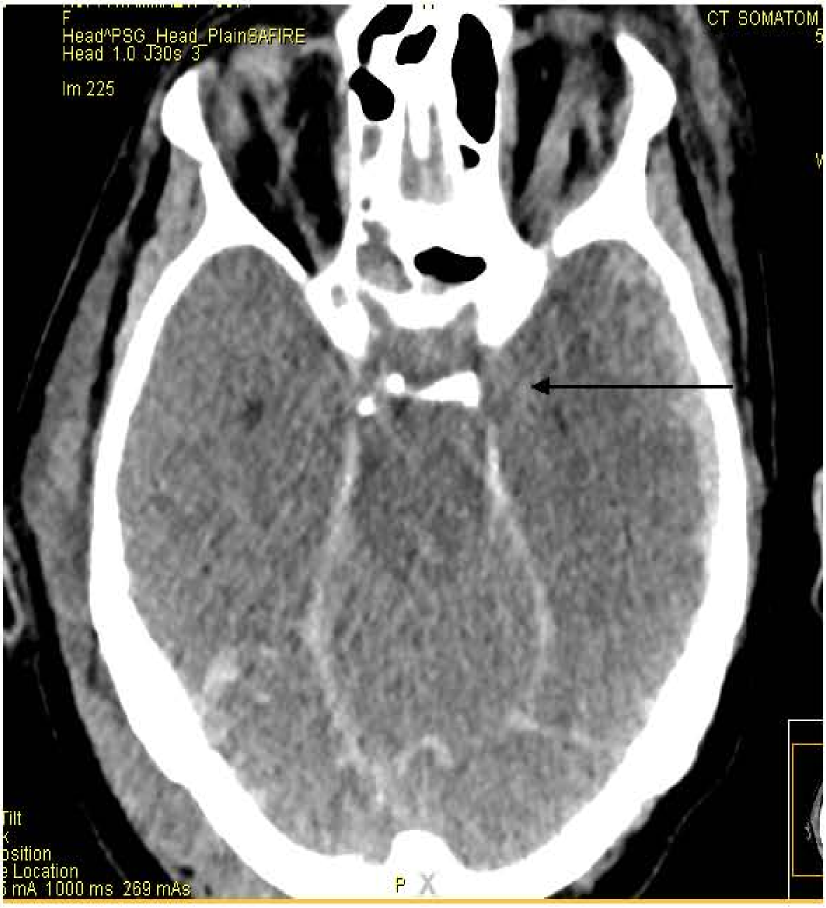


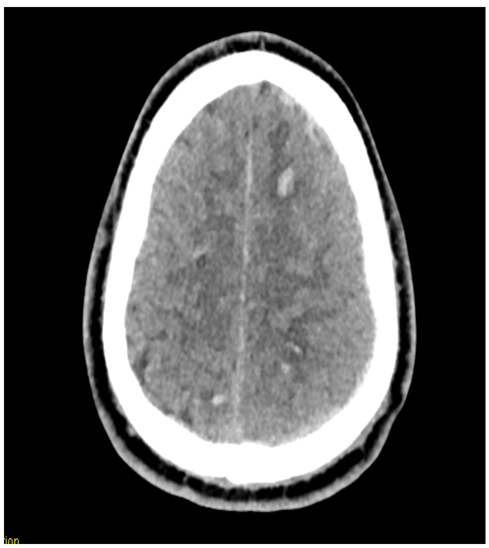
Figure 10 :Basal cistern effacement

Grade 5

Figure 11(a) : Intraventricular haemorrhage

Figure 11(b) : Hemorrhage in corpus callosum

.



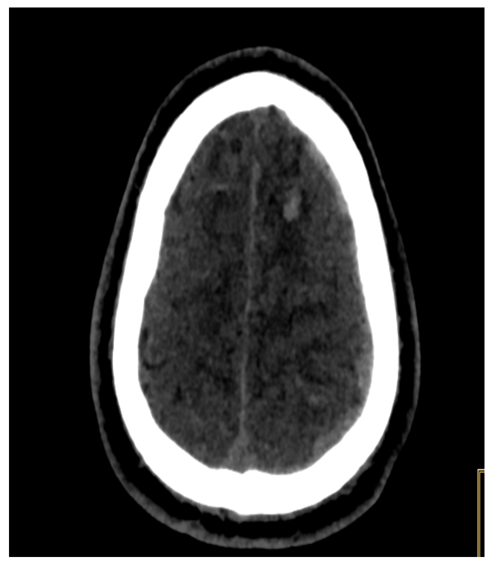


Figure 12 (a) subarachnoid hemorrhage

Figure 12 (b) subdural hemorrhage

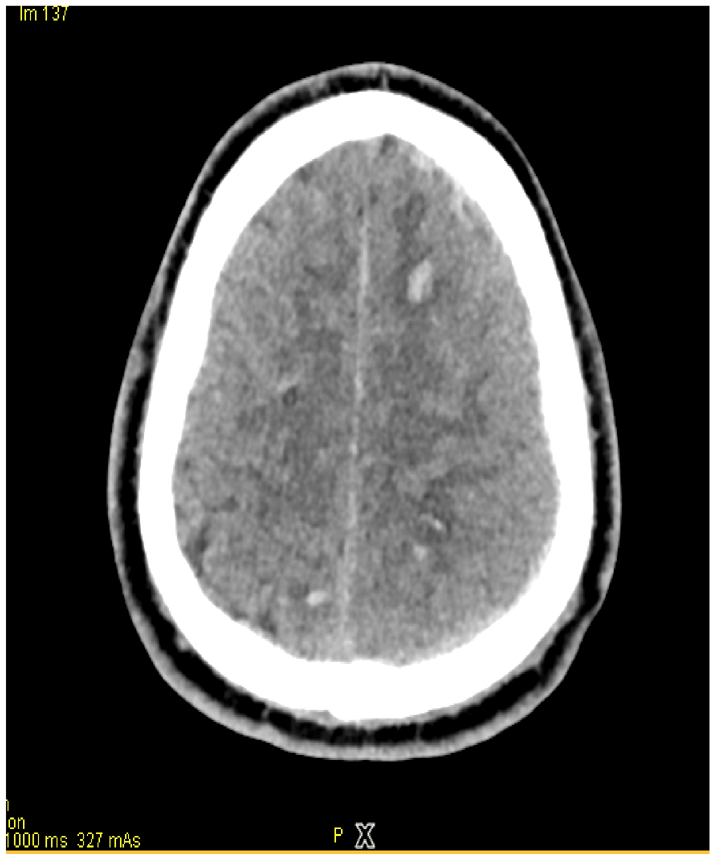


Figure 13 : Hemorrhagic contusion

Grade 5

Figure 14(a) subdural hemorrhage

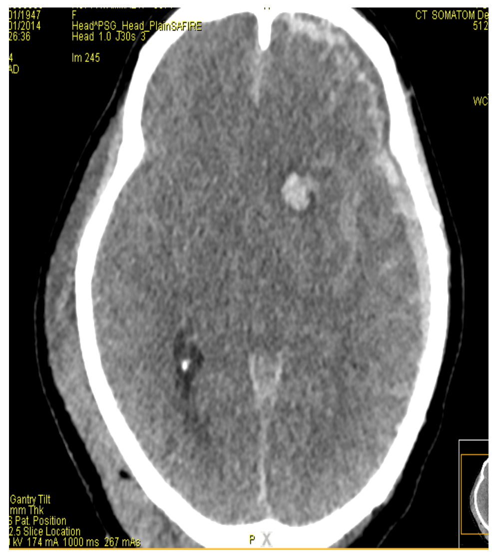


Figure 14(b) hemorrhagic contusion

Figure 15 subfalcine herniation

Figure 16(a) Midline shift

Figure 16 (b) basal cistern effacement

Figure 17. Subarchnoid hemorrhage

DAI grade 3

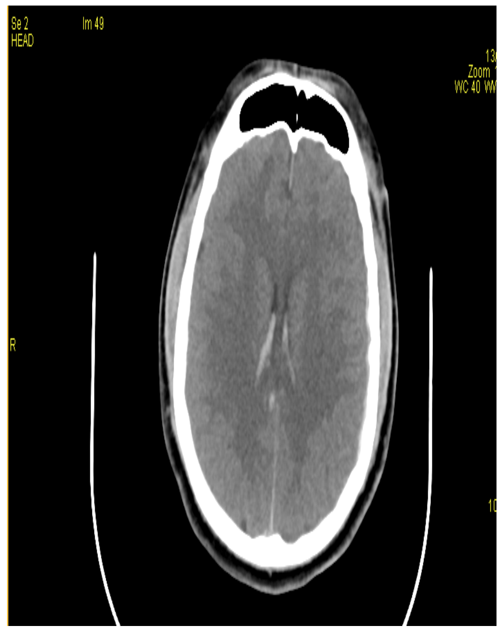


Figure 18(a) haemorrhagic foci
Haemorrhage

Figure 18(b)intraventricular
in brain stem

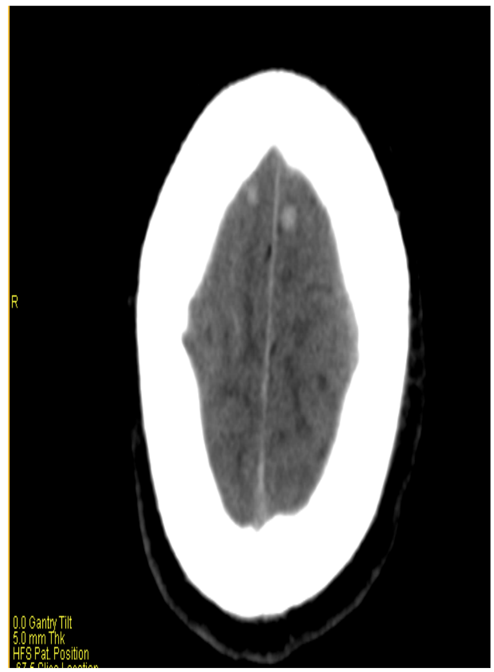


Figure 19(a) subdural hemorrhage   Figure 19(b) hemorrhagic contusion

Grade3

Figure 20(a) hemorrhagic contusion

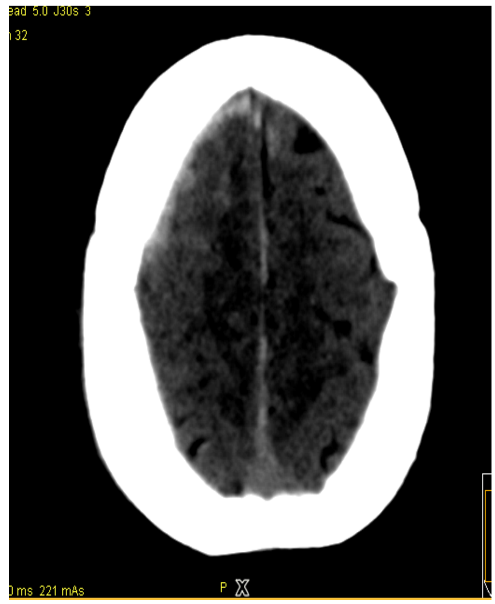


Figure 20(b) subdural hemorrhage

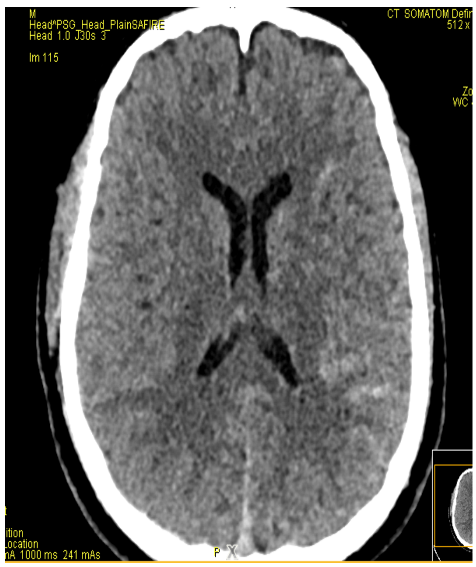


Figure 21(a) Subarachnoid

hemorrhage

Figure 21(b) Hemorrhagic

contusion

Figure 22 hemorrhagic cistern

Grade2

Figure 23(a) subfalcine herniation

Figure 23(b) Extradural hemorrhage

Figure 24(a) Hemorrhagic contusion

Figure 24(b) Midline shift

Figure 25 Subarchnoid hemorrhage

Figure 26(a) Subdural hemorrhage

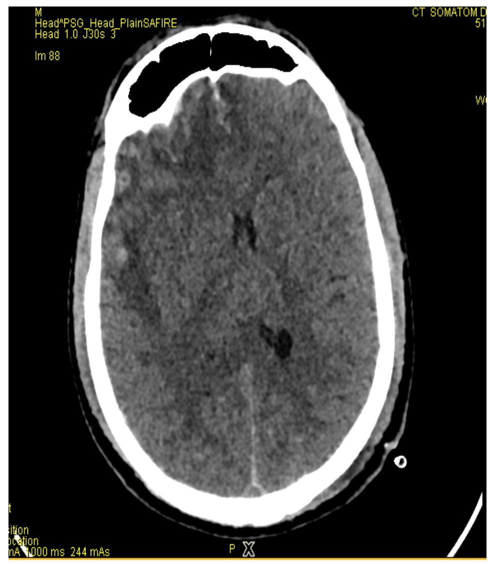
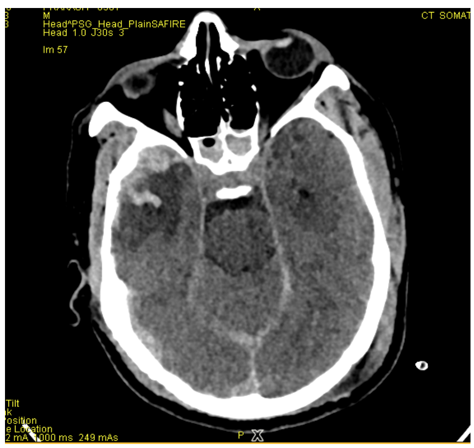


Figure26 (b) Hemorrhagic contusion



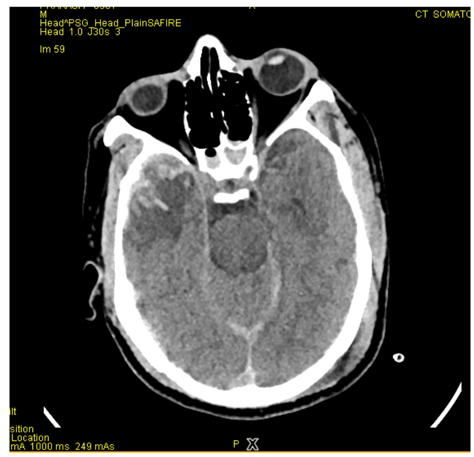


Figure 27(a) Extradural hemorrhage

Figure27(b) subarachnoid hemorrhage

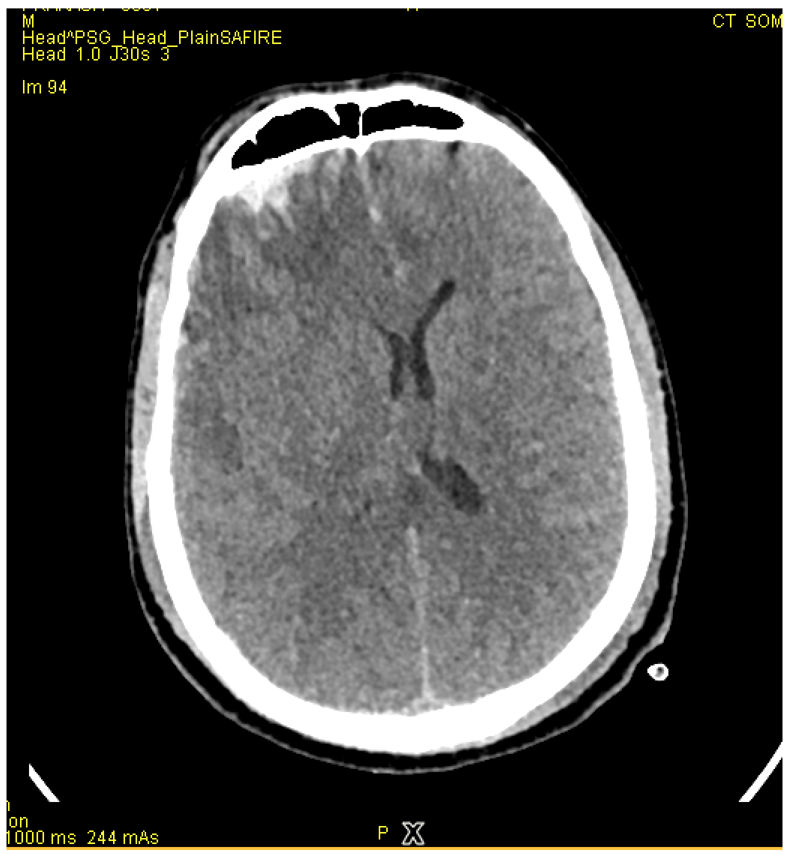


Figure 28 Midline shift

64 year old male with grade 1 outcome

Figure 29(a)Extradural hemorrhage

Figure29 (b) subdural hemorrhage

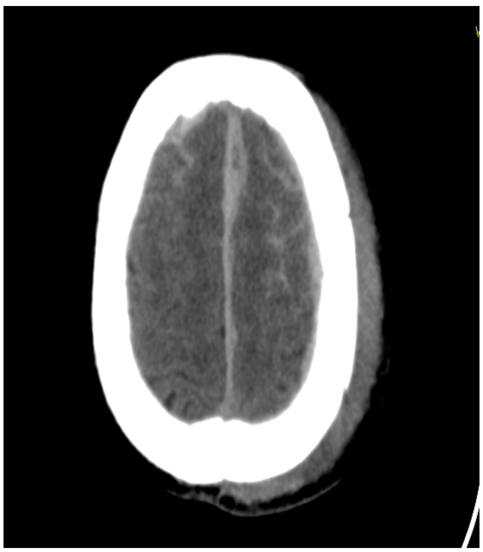


Figure 30(a) subarachnoid hemorrhage Figure30(b) Hemorrhagic contusion

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BIBLIOGRAPHY

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ANNEXURES

ANNEXURES

TABLES

GRAPH

MASTER CHART

S. NO	NAME	ID NO	AGE	GCS	EDH	SDH	SA H	CONT USION	IVH		BASAL CISTERN		MIDLINE SHIFT			DAI	HERINIATION						surgery	NO DAYS IN HOSPITAL				OUT COME
											comp	effacd	1-5 mm	5-10	>10		SF	V	C	TC	TA	TO			**1-5days**	**5-10days**	**>10days**	
1	subash	I13023785	19/M	9	x		x						x											14 days			*	grade 1
2	nazeema	I13038105	44/F	9	x		x	x				x	x										x	13days			*	grade 1
3	Kuppayamal.v	I14002179	55/M	6		x	x	X				x		x			x	x										grade 5
4	Bakyam	I14001789	38/F	12		X	x																	7 days		*		grade1
5	Rajendran	I12007197	46/M	10			X	x																1days		*	*	grade 1
6	karuppasamy	I13024418	45/M	4		X	x	x						x										7 days		*		grade 1
7	murugesan	I13029666	31/M	12	x	X		x					x											14 days			*	grade 1
8	elangovan	I13024418	49/M	12	X		x	X																30days			*	grade 1
9	Devaramal	I14001419	55/F	8		X	x	x				x	x										x	14days	*			grade 1
10	unnikrishnan	I13004409	65/M	9		x	x	x					x											27days			*	grade 5
11	gopal	I13017843	45M	10		x	x	x					x											18 days			*	grade 5
12	dhanalakshmi	I13016362	61/F	3		x	x	x					x				x							3days	*			grade 5
13	Dilipkumar	I13012245	24/M	11	x	x	x						x											12 days		*		grade 1
14	sivaraj	I14002008	40/M	10		x	x	X					x											12days	*			grade1
15	Robert stalin	I13017167	26/M	2		x	x	x	x														s	38days			*	grade 1
16	Duraisamy	I14018355	61/M	5			x	x					x											1day	*			grade 5
17	MANIAN	I12008681	34/M	6			x	x																13days			*	grade 2
18	venugopal	I12007075	23/M	11			x																	15days		*		grade 1
19	gowtham raj	I12004192	18/M	6			x	x																26 days			*	grade1
20	Boopathy	I13003175	35/M	12		x	x	x	x															11 days			*	grade 1
21	Selvaraj M	I13013303	29/M	12		x	x	x				x												18 days			*	grade 1
22	tamilvanan	I13013277	19/M	4		x	x	x	x							g3								60 days			*	grade 4
23	arasan	I13025385	65/M	10	x	x	x	x																30days			*	grade 1
24	nagaraj	I12025427	36/M	11		x	x	x															S	150 days			*	grade 2
25	ramolini	I12025562	22/F	4		x	x	x						x									s	90 days			*	grade 1
26	Prakash	I13014613	30/M	3	x	x		x						x										39 days			*	grade 2
27	gajendran	I12033174	27/M	11		x	x	x															s	13 days			*	grade 2

28	Robetr Stalin	I13017167	25/M	2		x	x	x	x					x										20days			*	grade 1
29	marichamy	I12036102	25/M	11/15			x									g2							s	17 days			*	grade 1
30	natchimuthu	I13027015	51/M	2/15		x	x	x				x												21day			*	grade 5
31	guhanesan	I13024817	31/M	9/15		x	x	x																4days	*			grade 1
32	Krishnamoorthy	I13021321	38/M	5		x	x	x				x	x										s	15 days			*	grade 1
33	Udayakumar	I13014444	35/M	8		x	x	x																10days		*		grade 2
34	ramesh	I13020392	29/M	6		x	x	x															s	25days			*	grade 3
35	palani	I13028170	35/M	2		x	x	x				x			x								x	9days	*			grade 5
36	sankar	I13011320	43M	6		x	x	x				X	x										x	4days	*			grade 3
37	chelladurai	I12012886	51/M	9			x	x																6days		*		grade 1
38	Chinasamy	I13018593	57/M	10		x	x	x																7 days		*		grade 1
39	vijalakshmi	I13011992	50/F	5	X	x	X					x	x										s	90 days			*	grade 1
40	subramaniam	I12013842	43/M	10	x			x																8days		*		grade 1
41	venkatraj	I12023221	28/M	5	x		x	X							x		x							64 days			*	grade 2
42	Rangasamy	I1301852	42/M	8		x	x	x																9days		*		grade 1
43	gokul ranjith .b	I13020056	34/M	8	x	x					x		x										x	7		*		grade 1
44	ARUSAMY	I13020024	30/M	12		X	X	X																3 DAYS	*			grade 1
45	arulraj	I12016788	18/M	12		x	x	x																21 days			*	grade 1
46	palani .k	O13066747	33/M	2	x	x	x	x															x	10 days		*		grade 1
54	subbulakshmi	I13030349	59/F	12			x	x						x										13days			*	grade 2
55	ananda padma naban	I13031007	65/M	2		x	x	x							X								S	30DAY S			*	grade 1
56	palanisamy	I13032155	40/M	10		x	x	x																20 days			*	grade 1
57	venkitapathy	I13032082	44/M	6		X	x								x		X							2days	*			grade 5
58	palanisamy.k	I13032372	70/M	5		x	x	x						x										20 days	*			grade 5
59	veramuthu	I13033779	43/M	7		x	x	x																10 days		*		grade 5
60	myilathal	I13032499	50/F	11	x	x	x	x																8days		*		grade 1
61	elankathir	I13031608	33/M	12	x		x	x																9 days		*		grade 1
62	myilsamy	O12009271	50/M	14	x	x	x	x																14 days			*	grade 1
63	chandra mohan	I14018792	44/M	2		x	x	x	x			x												7 days				grade 5
64	muthusamy	I13019791	41/M	11	x	x	x	x															x	9days		*		grade 1

65	hidyathula	I13032223	48/M	15			x	x																4 days	*			grade 1
66	ranganathan	I14012797	41/M	12	x	x	x	x																15 days			*	grade 1
67	Karthikeyan	I13029281	30/M	12	X																			10 days		*		grade 1
68	mohana sundaram	I14016306	36/M	7			x	x								g2								20days			*	grade 1
69	sathish	O13073555	33/M	9	x		x	x																10days		*		grade 1
70	priyadharshini	O14043640	27/F	6			x		x			x												1day	*			grade 4
71	ponraj	I14007677	44/M	3		X	x								x									1day	*			grade 5
72	anjula	I13029444	60/F	9	x	x		x				x		x									x	30 days			*	grade 1
73	Duraisamy	I14014269	51/M	3			X		X															12days			*	grade 5
74	Ibrahim	I14013994	45/M	8		x	x	x															x	28 days			*	grade 3
75	gurusamy	I14013559	40/M	6		x	x	x																14 days			*	grade 1
76	faizal	I14010143	35/M	2		x	x	x	x							g2								10days			*	grade 5
77	saraswathi	I14010485	36/F	12			x	x	x														x	65days			*	grade 1
78	sundaraj	I14009531	44/M	10		x							x										x	24 days			*	grade 5
79	shajahan	I14012153	48/M	8			x	x					x										x	29days			*	grade 1
80	senthil kumar	I14009673	29/M	7			x	x								g2							x	15days			*	grade 1
81	arunkumar	I14007591	28/M	7	x	x	x	x				x	?x										x	21days			*	grade 1
82	muthusamy	I14007652	55/M	8		x	x	x	x															11days			*	grade 1
83	kanniammal	I14011451	44/F	7			x	x	x															1 day	*			grade 5
84	senthil kumar	I14009673	32/M	7			x	x								g2								15 days			*	grade 1
85	selvi	I14008663	28/F	7	x	x		x																28 days			*	grade 1